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# Effect of Potassium, Magnesium and Boron on Yield and its Components of Eggplant in Siwa Oasis

[1]M.R. Hafez and [2]F.A. EL- Azizy

[1]Plant Production Department, Desert Research Center, Cairo, Egypt
[2]Soil Fertility and Microbiology Department, Desert Research Center, Cairo, Egypt

**Abstract:** Two field experiments were carried out in Siwa Oasis Research Station, Desert Research Center to study the effect of fertilization with potassium (K), magnesium (Mg) and boron (B) on the growth character, yield and chemical composition of Eggplant (Black King F1) during 2014/2015 and 2015/2016 seasons in Khimisah Experimental Farm. The main factor (B) was used as foliar spray at rates of 0, 10 and 20 ppm while the sub main factors (K and Mg) were added to the soil at rates of 100 and 200 kg $K_2SO_4$/fed; 50 and 100 kg Mg $SO_4$/fed. as single or dual soil application. The results showed significant effect of K and Mg fertilization as a soil application as well as spraying application of B on all the investigated growth parameters (plant height, number of branches, fresh weight /plant and chlorophyll content). The best treatment that gave higher increase of growth characters were (200 kg $K_2SO_4$/fed +50kg Mg $SO_4$ + 20 ppm of B) in both seasons. There were significant positive effects for both soil and foliar application on all investigated total yield of fruits ton/fed. The highest mean values of total yield of fruits showed with application (200 kg $K_2SO_4$/fed + 50 kg $MgSO_4$ × 20 ppm of B) in 1st and 2nd seasons. The highest mean values for K uptake of shoot, fruits and Fe % in Eggplants fruits were obtained with application in both the studied seasons by the treatments of (200 kg $K_2SO_4$/fed + 100K g $MgSO_4$ × 20 ppm B ). Positive effects on the available extractable amount of N, P and K (ppm) in soil after harvesting for the single, double and triple interaction fertilizers K, Mg and B.

**Key words:** Soil fertilization · Foliar application · Nutrient uptake · Eggplant (*Solanum melongena* L.)

## INTRODUCTION

Khimisah experimental farm which is located at the latitude of 29°12' 34.5 N" and the longitude of 25° 24' 2.56" E., at Siwa Research Station, Matrouh Governorate. Desert Research Center, Egypt.

Eggplant (*Solanum melongena* L.) considered as one of the cultivated vegetable crops in many regions of the world, including tropical regions like India, China and Middle East Region, it is popular food and used for cooking. It is considered as a rich crop in carbohydrates, minerals and protein.

Potassium (K) is one of the essential major plant nutrients. Its importance in agriculture has increased with intensive agriculture as well as deficiency occurring in crop plants. Potassium deficiency reduces the growth and crop yield [1]. Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production. The production of ATP can regulate the rate of photosynthesis. Potassium also helps regulate the opening and closing of the stomata, which regulate the exchange of water vapor, oxygen and carbon dioxide [2]. Application of K fertilizer at rate (450 kg $K_2O$/ha), $K_2SO_4$ was found more effective than KCl on eggplant fruit yield, yield stability and eggplant fruit quality [3]. Zenia and Halina [4] reported that increasing potassium doses, regardless the fertilizer type considerably increased the element content in eggplant fruits. Nafiu, *et al*. [5] showed that, application of NPK 15:15:15 fertilizer at the rate of 200kg NPK/ha to eggplants on the field showed that the growth, dry matter and yield of eggplant can be greatly improved. The vegetative growth of pepper plants *including* plant height, leaf area and shoot fresh weight were significantly increased with

**Corresponding Author:** M.R. Hafez, Plant Production Department, Desert Research Center, Cairo, Egypt.

increased K. The highest yield fruit length/diameter ratio, fruit dry matter percentage, fruit vitamin C, total soluble solids and titratable acidity in chili pepper and bell pepper were obtained under application higher levels of K [6].

Magnesium (Mg) is an essential component of plant chlorophyll in addition to its role Mg aids in the formation of many plant compounds, such as sugars, proteins, oil and fats. It regulates the uptake of many plant nutrients, especially phosphorous and is involved in the translocation and metabolism of carbohydrates .It acts as a carrier for phosphorous, particularly into the seeds .Magnesium is also a specific activator of number of enzymes including certain of the transphosphorylass, dehydrogenases and carboxylases [7]. The dry weight of soybean plants increased significantly by increasing Mg application up to 24mg/L of $MgSO_4$.7 $H_2o$ with irrigation water [8].

Boron is an essential trace element required for the physiological functioning of higher plants. Deficiency of B is considered as a nutritional disorder that adversely affects the metabolism and plants growth. It is involved in the structural and functional integrity of the cell wall and membranes, ion fluxes across the membranes, cell division and elongation, nitrogen and carbohydrate metabolism, sugar transport, cytoskeletal proteins and plasmalemma-bound enzymes, nucleic acid, indoleacetic acid, polyamines, ascorbic acid and phenol metabolism and transport [9]. In commercial plant production, providing sufficient B supply is particularly important for yield development and fruit quality [10]. The foliar application with micronutrients especially B not only have major effects upon flower formation, carbohydrate and protein metabolism, but also increase pollen germination, pollen tube growth and yield [11]. Boron deficiency in crops is more widespread than the deficiency of any other micronutrients [12]. Asad, *et al.* [13] revealed that B deficiency affects the reproductive yield more than biomass yield, even in the absence of any visible sign of deficiency symptoms and therefore the requirement of B for reproductive development appears to be more for reproductive development than for vegetative growth. Atilla [14] stated that B application increased tissue phosphorus (P), potassium (K), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) concentrations. Abd El-Gawad and Osman [15] found that, foliar application of boric acid significantly stimulated many growth aspects of eggplant as plant height, leaf number, leaf area, haulm fresh and dry weight as compared with the control treatment.

The objective of this study is to know more about the role of potassium and magnesium fertilization followed by foliar spray with Boron to reach acceptable results of the growth, yield and chemical composition of eggplant plants under Siwa oasis conditions.

## MATERIALS AND METHODS

Two field experiments were conducted during 2014/2015 and 2015/2016 in the Experimental Station of the Desert Research Center at Khimisah, Siwa Oasis, south west of Marsa Matrouh Governorate, Egypt. The experiment aimed to study the response of Eggplant (Black King F1) cultivar to mineral fertilizer (K and Mg) and foliar application of B on growth parameters, yield and chemical composition of Eggplant (Black King F1) cultivar under Siwa Oasis conditions.

**The Studied Treatments:** Experiments were conducted to study the effect of soil application with K as potassium sulphate and Mg as magnesium sulphate fertilizer *i.e.,* (check, 100, 200 k., 50Mg, 100 Mg, 100 k +50 Mg, 100 k +100 Mg, 200 k +50.Mg and 200 k +100 Mg Kg./fed.) and foliar application treatments with chelate boron (0, 10, 3 and 20 ppm B.).

Eggplant seedlings 35 days (Black King F1) were transplanted in field experimental farm at 50 cm distance between each plant on the ridge at $1^{st}$ November at the first seasons and the 10 of November at the second season. Plot area was 1/400 fed., (1 m.w ×12.5 m. L). Chicken manure was added at the rate of 10 $m^3$/fed. as well as calcium super-phosphate (15.5% $P_2O_5$) at a rate of 300 kg/fed., were added during soil preparation. Nitrogen fertilizer as ammonium sulphate (20.6% N) was added at rate of 250 kg /fed., the quantities were divided through drip irrigation system and applied at 5 times after 25, 35, 45, 55 and 65 days from sowing date.

Three different solution chelate boron concentrations were sprayed three times with an aqueous solution (0, 10, 20 ppm), where the first spray was performed after 30 days from sowing date, whereas, the second one and latter were applied after 40 and 50 days from sowing date. Soil application treatments, potassium and magnesium sulphate were divided into five equal parts through drip irrigation system after 30, 40, 50, 60 and 70 days from sowing date.

Table 1: Some physical and chemical properties of the experimental soil

| | | Soluble anions (me/l) | | | | | Soluble cations (me/l) | | | | available nutrients ppm | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil depth (cm) | Texture class | $HCO_3^-$ | $SO_4^=$ | $Cl^-$ | pH soil paste | EC $dSm^{-1}$ | $Ca^{++}$ | $Mg^{++}$ | $Na^+$ | $K^+$ | N | P | K | B |
| 0 - 25 | Sandy loam | 0.75 | 0.85 | 4.25 | 6.7 | 0.58 | 1.15 | 0.45 | 3.92 | 0.33 | 13 | 3 | 2 | 0.21 |

pH: Acidity E.C.: Electrical conductivity me/l: milli equivalent per liter

Table 2: Chemical analysis of the irrigation water

| | | Soluble cations (me/l) | | | | Soluble anions (me/l) | | |
|---|---|---|---|---|---|---|---|---|
| pH | EC. $dSm^{-1}$ | $Ca^{++}$ | $Mg^{++}$ | $Na^+$ | $K^+$ | $HCO_3^-$ | $SO_4^=$ | $Cl^-$ |
| 7.1 | 5.54 | 10.1 | 13.32 | 39.4 | 1.17 | 9.35 | 15.1 | 39.5 |

pH: Acidity, EC.: Electrical conductivity, $dSm^{-1}$: decseime per meter

The physical and chemical soil characteristics were determined according to Page *et al*. [16] and Klute [17], respectively as recorded in Table (1). The chemical analysis of irrigation water was carried out using the standard method of Page *et al*. [16] and presented in Table (2).

**Experiment Design:** The experiment design was split plot design with three replicates; the experiment included 27 treatments in two factors, foliar applications of B were three rates, in main plots and the nine rates mineral fertilization in sub- plots.

**Data Recoded:** After 120 days from planting, ten plants from each experimental plot were randomly take for recording vegetative growth characteristics, *i.e*., plant height, number of branches/plant, fresh weight/plant (gm) and dry weight of shoot kg /fed., total yield of ton/fed. chlorophyll content and N, P, K uptake of fruits(kg /fed).

uptake = (dry weight per fruit X % to elements)/100

**Total Yield:** During harvest time ten fruits were randomly taken from each experimental plot from all pickings during the entire season were counted and weighed for calculating total yield/plant as well as per fed.

**Methods of Analysis:** Total chlorophyll content was measured in the upper fourth leaf using Minolta Chlorophyll Meter SPAD-502, dry materials of plant samples (shoots and fruits) at harvesting were wet digested using mixture of $H_2SO_4$ and $HClO_4$ as recommended by Peter burgski [18] and the following chemical analyses were carried out:

Potassium was determined by flame photometrically. N, P, K and Fe were determined according to the methods described by Black *et al*. [19] and Chapman and Pratt [20]. Available P, K and B in soil according to Soltanpour and Schwab [21], Available N extracted by 2.0 M KCL as described by Rowell [22]. All data were statistically analysis according to Snedecor and Cochran [23]. The differences between means were tested by L.S.D. at 5% level of significance Steel [24].

## RESULTS AND DISCUSSION

**Growth Characters:** Data recorded in Table (3) showed the effect of B on plant height, number of branches, fresh weight of shoot /plant. Results indicated that, there are significant effects for foliar application of B on all the investigated growth parameters. The high rate of B gave the best values of growth characters this effect may be due to the role of B in plant growth, due to its effect on cell wall structure, membrane stability, sugar transportation, phenol and carbohydrate metabolism Broadley, *et al.* [25] and Brown, *et al.* [26]. These results are in agreement with Abd El-Gawad and Osman [15].

As regard to the effect of fertilizer with K or Mg; a significant increase was noticed on plant height, No. of branches, fresh weight of shoots/plant, when the eggplant fertilization with 100 Kg. of K +50 Kg Mg or 200 Kg. of potassium + 50 Kg. magnesium compared with control treatments in both tested seasons. These results are due to the role of potassium and magnesium fertilization on solanaceae. These results are in agreement with Miller [7], Bernd and Svetlana [27], Nafiu, *et al.* [5] and Sedighe *et al*. [6].

Data reveal that a significant interaction effect between (K×B), (Mg × B) and (K + Mg× B) fertilizers on the growth characters in both studied two seasons. The best treatment that gave higher increases of growth characters were (100 kg. $K_2SO4$ +50kg. Mg $SO_4$. + 20 ppm B) in both studied two seasons, compared with control and other treatments. This effect due to integrated and balance nutrients management leads to increase the efficiency of all nutrients applied thus decreasing the used amount of fertilizers.

Table 3: Effect of K, Mg and B fertilizer on plant height, number of branches and fresh weight g/plant of Eggplant during 2014/2015 and 2015/2016

| | First season | | | | Second season | | | |
|---|---|---|---|---|---|---|---|---|
| | B foliar spray (ppm) | | | | B foliar spray (ppm) | | | |
| Fertilizer treatments | 0 | 10 | 20 | Mean (B) | 0 | 10 | 20 | Mean (B) |
| | | | | Plant height (cm) | | | | |
| Control | 59.67 | 70.33 | 76.67 | 68.89 | 71.60 | 84.40 | 92.00 | 82.67 |
| 100 K | 66.00 | 75.67 | 77.67 | 73.11 | 79.20 | 90.80 | 93.20 | 87.73 |
| 200 K | 71.00 | 76.67 | 79.67 | 75.78 | 85.20 | 92.00 | 95.60 | 90.93 |
| 50 Mg | 67.67 | 71.67 | 81.33 | 73.56 | 81.20 | 86.00 | 97.60 | 88.27 |
| 100 Mg | 73.33 | 75.00 | 77.00 | 75.11 | 88.00 | 90.00 | 92.40 | 90.13 |
| 100 K+50 Mg | 74.67 | 85.00 | 91.67 | 83.78 | 89.60 | 102.00 | 110.00 | 100.53 |
| 100 K + 100 Mg | 75.33 | 76.67 | 81.67 | 77.89 | 90.40 | 92.00 | 98.00 | 93.47 |
| 200 K+ 50 Mg | 80.00 | 85.67 | 85.67 | 83.78 | 96.00 | 102.80 | 102.80 | 100.53 |
| 200 K+100 Mg | 71.33 | 77.33 | 80.67 | 76.44 | 85.60 | 92.80 | 96.80 | 91.73 |
| Mean (A) | 71.00 | 77.11 | 81.33 | --- | 85.20 | 92.53 | 97.60 | --- |
| LSD at 0.05 | A= 1.75 | B=0.89 | XB=2.80 | | A=2.10 | B=1.07 | AXB=3.36 | |
| | | | | Number of branch/ plant | | | | |
| Control | 3.67 | 4.67 | 5.67 | 4.67 | 4.77 | 6.07 | 7.37 | 6.07 |
| 100 K | 4.67 | 6.33 | 7.00 | 6.00 | 6.07 | 8.23 | 9.10 | 7.80 |
| 200 K | 5.33 | 6.33 | 7.33 | 6.33 | 6.93 | 8.23 | 9.53 | 8.23 |
| 50 Mg | 4.67 | 5.67 | 7.33 | 5.89 | 6.07 | 7.37 | 9.53 | 7.66 |
| 100 Mg | 4.67 | 5.00 | 5.67 | 5.11 | 6.07 | 6.50 | 7.37 | 6.65 |
| 100 K+50 Mg | 6.00 | 7.00 | 8.67 | 7.22 | 7.80 | 9.10 | 11.27 | 9.39 |
| 100 K + 100 Mg | 6.33 | 6.67 | 7.67 | 6.89 | 8.23 | 8.67 | 9.97 | 8.96 |
| 200 K+ 50 Mg | 6.67 | 6.67 | 6.67 | 6.67 | 8.67 | 8.67 | 8.67 | 8.67 |
| 200 K+100 Mg | 6.33 | 6.67 | 8.00 | 7.00 | 8.23 | 8.67 | 10.40 | 9.10 |
| Mean (A) | 5.37 | 6.11 | 7.11 | --- | 6.98 | 7.94 | 9.24 | --- |
| LSD at 0.05 | A= 0.70 | B=0.38 | AXB= 1.18 | | A= 0.91 | B= 0.49 | AXB=1.54 | |
| | | | | Fresh weight g/plant | | | | |
| Control | 178.33 | 221.00 | 289.67 | 229.67 | 205.08 | 254.15 | 333.12 | 264.12 |
| 100 K | 440.00 | 431.67 | 553.33 | 475.00 | 506.00 | 496.42 | 636.33 | 546.25 |
| 200 K | 244.00 | 395.00 | 485.00 | 374.67 | 280.60 | 454.25 | 557.75 | 430.87 |
| 50 Mg | 291.00 | 436.67 | 441.67 | 389.78 | 334.65 | 502.17 | 507.92 | 448.25 |
| 100 Mg | 321.67 | 358.33 | 380.00 | 353.33 | 369.92 | 412.08 | 437.00 | 406.33 |
| 100 K+50 Mg | 521.00 | 526.67 | 661.67 | 569.78 | 599.15 | 605.67 | 760.92 | 655.25 |
| 100 K + 100 Mg | 436.67 | 451.00 | 495.00 | 460.89 | 502.17 | 518.65 | 569.25 | 530.02 |
| 200 K+ 50 Mg | 341.00 | 569.67 | 600.00 | 503.56 | 392.15 | 655.12 | 690.00 | 579.09 |
| 200 K+100 Mg | 550.67 | 562.00 | 601.67 | 571.45 | 633.27 | 646.30 | 691.92 | 657.16 |
| Mean (A) | 369.37 | 439.11 | 500.89 | --- | 424.78 | 504.98 | 576.02 | --- |
| LSD at 0.05 | A=8.12 | B= 4.88 | AXB=15.37 | | A= 9.34 | B= 5.62 | AXB=17.67 | |

K= $K_2SO_4$ Mg= Mg $SO_4$ B=Boron

Table 4: Effect of K, Mg and B fertilizer on chlorophyll (mg /10g) of Eggplant during 2014/2015 and 2015/2016 seasons.

| | First season | | | | Second season | | | |
|---|---|---|---|---|---|---|---|---|
| | B foliar spray (ppm) | | | | B foliar spray (ppm) | | | |
| Fertilizer treatments | 0 | 10 | 20 | Mean (B) | 0 | 10 | 20 | Mean (B) |
| Control | 32.47 | 38.53 | 39.53 | 36.84 | 34.74 | 41.23 | 42.30 | 39.42 |
| 100 K | 35.57 | 39.13 | 45.12 | 39.94 | 38.06 | 41.87 | 48.28 | 42.74 |
| 200 K | 35.97 | 42.00 | 44.53 | 40.83 | 38.48 | 44.94 | 47.65 | 43.69 |
| 50 Mg | 37.17 | 41.00 | 45.20 | 41.12 | 39.77 | 41.62 | 48.36 | 43.25 |
| 100 Mg | 36.77 | 40.47 | 49.73 | 42.32 | 39.34 | 43.30 | 53.21 | 45.28 |
| 100 K+50 Mg | 39.43 | 44.33 | 54.57 | 46.11 | 42.19 | 47.44 | 58.39 | 49.34 |
| 100 K + 100 Mg | 39.93 | 41.53 | 48.30 | 43.25 | 42.73 | 44.44 | 51.68 | 46.28 |
| 200 K+ 50 Mg | 42.67 | 43.53 | 46.07 | 44.09 | 45.65 | 46.58 | 49.29 | 47.17 |
| 200 K+100 Mg | 37.43 | 45.40 | 50.97 | 44.60 | 40.05 | 48.58 | 54.53 | 47.72 |
| Mean (A) | 37.49 | 41.77 | 47.11 | --- | 40.11 | 44.44 | 50.41 | --- |
| LSD at 0.05 | A= 0.75 | B=0.49 | AXB=1.54 | | A= 0.77 | B=0.54 | AXB=1.69 | |

K= $K_2SO_4$ Mg= Mg $SO_4$ B=Boron

Data in Table (4) show that there were significant differences among most of B foliar application treatments on total chlorophyll. 20 ppm B foliar application gave the highest value on chlorophyll compared with control and other treatments in both tested seasons. These results are partially in accordance with those obtained by Abd El-Gawad and Osman [15] and Shireen *et al*. [9].

Fertilizer soil application at rate of 100 Kg. K +50 kg Mg gave the highest values for total chlorophyll content compared with other fertilizer treatments in both tested seasons. These results may be due to the positive role of the K and Mg together and the increased concentration of these fertilizers may be unhelpful. These results are agreed with those obtained by Moussa 1 [8] and Dotaniya *et al*. [1].

As shown in Table 4, it can be concluded that the most significant effect interaction treatment was the 100 Kg. potassium +50 kg. magnesium application and 20 ppm Boron foliar application in Chlorophyll eggplant plant. Through both studied seasons, the interaction treatment at rate 100 Kg. potassium +50 kg. magnesium with 20 ppm B gave the highest significant increases percentage compared to other treatments.

**Total Yield:** Data presented in Table (5) indicated that there were significant positive effects of foliar fertilizer with B at rate 20 ppm on total yield (ton/fed) in both seasons. The gradually increased in total yield might be due to the increase of B content in plant; this is reflected on the increase upon flower formation, carbohydrate and protein metabolism and also increase pollen germination, pollen tube growth and yield. These results are in agreement with those obtained by Gerendas and Sattelmacher [11], Gupta [12], Asad, *et al.* [13] and Shireen *et al*. [9].

Concerning the effect of K and Mg fertilization on total yield of fruits (ton/fed) of eggplant plant; the soil application at rate 100 Kg. potassium +50 kg. Magnesium gave a significant increased compared with control and other treatments. These results may be due to the role of K to translocation of the newly synthesized photosynthates and the mobilization of the stored materials to fruits beside the role of Mg specific activator of a number of enzymes including certain of the transphosphorylass, dehydrogenases. These results were true in both tested seasons. These results are in agreement with By Ni Wuzhong [3]; Zenia and Halina [4]; Nafiu, *et al.* [5] and Sedighe *et al.* [6].

The most significant effect interaction treatments on yield of eggplant plant was the mixed of dual application of K and Mg mineral fertilizer (100 Kg. potassium +50 kg. magnesium) with B foliar spry at rate 20 ppm, whereas the lowest one was the single fertilizer with K or Mg application without B foliar spry in both seasons.

**Mineral Content and Uptake:** Data presented in Table (6) shows the potassium uptake in eggplant plant. Also, Table (8) shows the fruit content of the nitrogen, phosphorus and potassium. Eggplant plants foliar fertilizer with B at rate of 20 ppm showed a significant increase in N, P and K plant uptake and fruits content throughout two studied seasons, increasing application of B from control to 20 ppm B increased N, P and K content and uptake in fruits and shoots respectively. These results may be attributed to the important role of B, it plays a very critical key in cell-wall synthesis, carbohydrate metabolism, RNA metabolism, indole acetic acid metabolism, building membranes, which encourages increasing of growth and absorption of nutrient by increasing foliar spray of B . These results are in agreement with Atilla [14].

With respect to, the effect of different rates from K or Mg together or single fertilization on K uptake of shoot and fruits content of eggplant. The highest results were noticed with fertilizer soil application at rate 200 Kg. potassium +100 kg magnesium in both tested seasons. These results may be due to the important role of K and Mg to increase root growth and reduce water loss and aids photosynthesis; the mobilization of the stored materials to fruits, which encourages increasing of growth by the increasing the absorption of K. these results agree with Miller [7]; Moussa [8] and Dotaniya *et al*. [1].

As regard to the interaction effect between B foliar fertilizer with K or Mg fertilizer, significant effect were the mixed of dual application, the highest mean values for K uptake of shoot and menial content in eggplants fruits with the treatments at rate 200 Kg. potassium +100 kg magnesium with 20 ppm B in both growing seasons. This effect due to integrated and balance nutrients management leads to increasing the efficiency of all nutrients applied thus, increasing the amount nutrients uptake of shoot and fruits eggplant.

Data in Table (7) indicate that there were significant differences among most of all foliar spray applications treatments, where the foliar application at rate 20 ppm B showed the highest significant effects on K fruit uptake in the 1$^{st}$ and 2$^{nd}$ seasons.

Table 5: Effect of K, Mg and B fertilizer on total yield (ton/fed.) of Eggplant during 2014/2015 and 2015/2016 seasons

| | First season | | | | Second season | | | |
|---|---|---|---|---|---|---|---|---|
| | B foliar spray (ppm) | | | | B foliar spray (ppm) | | | |
| Fertilizer treatments | 0 | 10 | 20 | Mean (B) | 0 | 10 | 20 | Mean (B) |
| | | | | Total yield ton/fed | | | | |
| Control | 4.46 | 6.92 | 8.27 | 6.55 | 4.87 | 7.54 | 9.02 | 7.14 |
| 100 K | 6.37 | 8.31 | 11.86 | 8.85 | 6.94 | 9.06 | 12.92 | 9.64 |
| 200 K | 7.88 | 9.15 | 11.41 | 9.48 | 8.59 | 9.98 | 12.44 | 10.34 |
| 50 Mg | 5.15 | 6.34 | 7.81 | 6.43 | 5.61 | 6.91 | 8.52 | 7.01 |
| 100 Mg | 5.16 | 6.36 | 10.19 | 7.24 | 5.63 | 6.93 | 11.11 | 7.89 |
| 100 K+50 Mg | 8.95 | 13.35 | 16.64 | 12.98 | 9.76 | 14.55 | 18.14 | 14.15 |
| 100 K + 100 Mg | 8.69 | 11.10 | 13.73 | 11.17 | 9.47 | 12.10 | 14.96 | 12.18 |
| 200 K+ 50 Mg | 7.32 | 8.37 | 10.56 | 8.75 | 7.97 | 9.12 | 11.51 | 9.53 |
| 200 K+100 Mg | 5.95 | 8.14 | 11.66 | 8.58 | 6.49 | 8.87 | 12.70 | 9.35 |
| Mean (A) | 6.66 | 8.67 | 11.35 | --- | 7.26 | 9.45 | 12.37 | --- |
| LSD at 0.05 | A= 0.39 | B=0.24 | AXB=0.77 | | A= 0.42 | B=0.27 | AXB=0.84 | |

K= $K_2SO_4$ Mg= Mg $SO_4$ B=Boron

Table 6: Effect of K, Mg and B fertilizer on K uptake kg/ fed. in shoot of Eggplant during 2014/2015 and 2015/2016 seasons.

| | First season | | | | Second season | | | |
|---|---|---|---|---|---|---|---|---|
| | B foliar spray (ppm) | | | | B foliar spray (ppm) | | | |
| Fertilizer treatments | 0 | 10 | 20 | Mean (B) | 0 | 10 | 20 | Mean (B) |
| | | | | K uptake Kg./fed | | | | |
| Control | 2.06 | 2.57 | 3.42 | 2.68 | 2.22 | 2.78 | 3.69 | 2.90 |
| 100 K | 3.40 | 5.60 | 6.93 | 5.31 | 3.67 | 6.05 | 7.49 | 5.74 |
| 200 K | 7.07 | 4.22 | 4.53 | 5.27 | 7.63 | 7.57 | 9.82 | 8.34 |
| 50 Mg | 3.42 | 5.20 | 5.33 | 4.65 | 3.70 | 5.61 | 5.76 | 5.02 |
| 100 Mg | 3.76 | 4.22 | 4.53 | 4.17 | 4.06 | 4.56 | 4.89 | 4.50 |
| 100 K+50 Mg | 7.39 | 7.56 | 9.63 | 8.19 | 7.98 | 8.16 | 10.40 | 8.85 |
| 100 K + 100 Mg | 6.14 | 6.31 | 7.03 | 6.49 | 6.63 | 6.82 | 7.59 | 7.01 |
| 200 K+ 50 Mg | 5.10 | 8.62 | 9.29 | 7.67 | 5.51 | 9.31 | 10.04 | 8.29 |
| 200 K+100 Mg | 8.49 | 8.33 | 9.48 | 8.77 | 9.17 | 8.99 | 10.24 | 9.47 |
| Mean (A) | 5.20 | 5.85 | 6.69 | --- | 5.62 | 6.65 | 7.77 | --- |
| LSD at 0.05 | A= 0.16 | B=0.07 | AXB=0.2 | | A= 0.17 | B=0.08 | AXB=0.2 | |

K= $K_2SO_4$ Mg= Mg $SO_4$ B=Boron

Table 7: Effect of K, Mg and B fertilizer on K uptake kg/ fed. in fruit of Eggplant during 2014/2015 and 2015/2016 seasons

| | First season | | | | Second season | | | |
|---|---|---|---|---|---|---|---|---|
| | B foliar spray (ppm) | | | | B foliar spray (ppm) | | | |
| Fertilizer treatments | 0 | 10 | 20 | Mean (B) | 0 | 10 | 20 | Mean (B) |
| | | | | K uptake fruit Kg./fed | | | | |
| Control | 2.63 | 4.23 | 5.16 | 4.01 | 2.84 | 4.56 | 5.58 | 4.33 |
| 100 K | 4.10 | 5.48 | 8.01 | 5.86 | 4.42 | 5.91 | 8.66 | 6.33 |
| 200 K | 5.63 | 4.60 | 7.48 | 5.91 | 6.08 | 7.32 | 9.30 | 7.57 |
| 50 Mg | 3.44 | 4.29 | 5.42 | 4.38 | 3.72 | 4.63 | 5.85 | 4.73 |
| 100 Mg | 3.52 | 4.60 | 7.48 | 5.20 | 3.81 | 4.97 | 8.08 | 5.62 |
| 100 K+50 Mg | 6.46 | 10.06 | 12.88 | 9.80 | 6.97 | 10.87 | 13.91 | 10.58 |
| 100 K + 100 Mg | 6.68 | 8.75 | 11.06 | 8.83 | 7.22 | 9.45 | 11.95 | 9.54 |
| 200 K+ 50 Mg | 5.94 | 6.92 | 8.93 | 7.27 | 6.42 | 7.48 | 9.64 | 7.85 |
| 200 K+100 Mg | 5.09 | 7.09 | 10.38 | 7.52 | 5.50 | 7.65 | 11.21 | 8.12 |
| Mean (A) | 4.83 | 6.22 | 8.53 | --- | 5.22 | 6.98 | 9.35 | --- |
| LSD at 0.05 | A= 0.32 | B=0.20 | AXB=0.62 | | A= 0.34 | B=0.21 | AXB=0.67 | |

K= $K_2SO_4$ Mg= Mg $SO_4$ B=Boron

Table 8: Effect of K, Mg and B fertilizer on nutrient content in fruit of Eggplant during 2014/2015 and 2015/2016 seasons.

| | First season | | | | Second season | | | |
|---|---|---|---|---|---|---|---|---|
| | B foliar spray (ppm) | | | | B foliar spray (ppm) | | | |
| Fertilizer treatments | 0 | 10 | 20 | Mean (B) | 0 | 10 | 20 | Mean (B) |
| | | | | N in fruit | | | | |
| Control | 2.50 | 2.51 | 2.53 | 2.51 | 2.52 | 2.54 | 2.56 | 2.54 |
| 100 K | 2.56 | 2.57 | 2.58 | 2.57 | 2.59 | 2.60 | 2.61 | 2.60 |
| 200 K | 2.59 | 2.60 | 2.59 | 2.59 | 2.62 | 2.63 | 2.62 | 2.62 |
| 50 Mg | 2.56 | 2.59 | 2.59 | 2.58 | 2.59 | 2.61 | 2.62 | 2.61 |
| 100 Mg | 2.57 | 2.58 | 2.60 | 2.58 | 2.60 | 2.61 | 2.63 | 2.61 |
| 100 K+50 Mg | 2.64 | 2.67 | 2.69 | 2.67 | 2.67 | 2.70 | 2.72 | 2.69 |
| 100 K + 100 Mg | 2.67 | 2.67 | 2.70 | 2.68 | 2.70 | 2.70 | 2.72 | 2.71 |
| 200 K+ 50 Mg | 2.68 | 2.69 | 2.71 | 2.69 | 2.71 | 2.72 | 2.74 | 2.72 |
| 200 K+100 Mg | 2.68 | 2.70 | 2.72 | 2.70 | 2.71 | 2.73 | 2.75 | 2.73 |
| Mean (A) | 2.61 | 2.62 | 2.64 | --- | 2.63 | 2.65 | 2.66 | --- |
| LSD at 0.05 | A= 0.01 | B=0.01 | AXB=0.02 | | A= 0.01 | B=0.01 | AXB=0.02 | |
| | | | | P in fruit | | | | |
| Control | 0.13 | 0.13 | 0.14 | 0.13 | 0.14 | 0.14 | 0.15 | 0.14 |
| 100 K | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.16 | 0.15 |
| 200 K | 0.15 | 0.15 | 0.16 | 0.15 | 0.16 | 0.17 | 0.17 | 0.17 |
| 50 Mg | 0.14 | 0.14 | 0.15 | 0.14 | 0.15 | 0.15 | 0.16 | 0.15 |
| 100 Mg | 0.15 | 0.15 | 0.15 | 0.15 | 0.16 | 0.16 | 0.17 | 0.16 |
| 100 K+50 Mg | 0.16 | 0.16 | 0.17 | 0.16 | 0.17 | 0.18 | 0.18 | 0.18 |
| 100 K + 100 Mg | 0.16 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 |
| 200 K+ 50 Mg | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 |
| 200 K+100 Mg | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 | 0.19 | 0.19 | 0.18 |
| Mean (A) | 0.15 | 0.15 | 0.16 | --- | 0.16 | 0.17 | 0.17 | --- |
| LSD at 0.05 | A= ns | B=ns | AXB=ns | | A=ns | B=ns | AXB=ns | |
| | | | | K in fruit | | | | |
| Control | 0.91 | 0.94 | 0.96 | 0.94 | 0.98 | 1.02 | 1.04 | 1.01 |
| 100 K | 0.99 | 1.01 | 1.04 | 1.01 | 1.07 | 1.09 | 1.12 | 1.10 |
| 200 K | 1.10 | 1.11 | 1.13 | 1.11 | 1.19 | 1.23 | 1.25 | 1.22 |
| 50 Mg | 1.03 | 1.04 | 1.07 | 1.05 | 1.11 | 1.12 | 1.15 | 1.13 |
| 100 Mg | 1.05 | 1.11 | 1.13 | 1.10 | 1.13 | 1.20 | 1.22 | 1.19 |
| 100 K+50 Mg | 1.11 | 1.16 | 1.19 | 1.15 | 1.20 | 1.25 | 1.29 | 1.25 |
| 100 K + 100 Mg | 1.18 | 1.21 | 1.24 | 1.21 | 1.28 | 1.31 | 1.34 | 1.31 |
| 200 K+ 50 Mg | 1.25 | 1.27 | 1.30 | 1.27 | 1.35 | 1.38 | 1.40 | 1.38 |
| 200 K+100 Mg | 1.32 | 1.34 | 1.37 | 1.34 | 1.42 | 1.45 | 1.48 | 1.45 |
| Mean (A) | 1.10 | 1.13 | 1.16 | --- | 1.19 | 1.23 | 1.25 | --- |
| LSD at 0.05 | A= 0.01 | B=0.01 | AXB=0.02 | | A= 0.01 | B=0.01 | AXB=0.02 | |

K= $K_2SO_4$ Mg= Mg $SO_4$ B=Boron

With respect to K uptake by eggplant plant it can be concluded from results in Table (7) that the dual soil application (100 Kg. potassium +50 kg magnesium) resulted in the highest significant effects on eggplant K uptake followed by the soil application of 100 Kg. potassium +100 kg magnesium, these results were true in the 1st and 2nd season. These results are partially in accordance with those obtained by By Ni Wuzhong [3] and Zenia and Halina [4].

The most significant effective interacted treatment was the mixed of dual application of 100 Kg. potassium +50 kg magnesium and foliar fertilizer at rate 20 ppm B on K uptake in fruit of eggplant plant in both tested seasons.

Data in Table (9) evident that, the highest mean value of Fe ppm of plant and fruits eggplant recorded with the low rate application of B (10 ppm) in 1$^{st}$ and 2$^{nd}$ seasons respectively. The low concentration of B may be sufficient to Fe contain the plant and fruits compared with control treatment, although there is no clear difference between spraying with the highest level of B. These are in agreement with Atilla [14].

Table 9: Effect of K, Mg and B fertilizer on Fe (ppm) in plant of Eggplant during 2014/2015 and 2015/2016 seasons.

| | First season | | | | Second season | | | |
|---|---|---|---|---|---|---|---|---|
| | B foliar spray (ppm) | | | | B foliar spray (ppm) | | | |
| Fertilizer treatments | 0 | 10 | 20 | Mean (B) | 0 | 10 | 20 | Mean (B) |
| | | | | Fe in plant ppm | | | | |
| Control | 10.73 | 10.77 | 10.80 | 10.77 | 10.89 | 10.93 | 10.97 | 10.93 |
| 100 K | 11.73 | 11.78 | 11.80 | 11.77 | 11.91 | 11.95 | 11.98 | 11.95 |
| 200 K | 12.10 | 12.12 | 12.18 | 12.13 | 12.28 | 12.30 | 12.36 | 12.32 |
| 50 Mg | 11.82 | 11.90 | 11.95 | 11.89 | 11.99 | 12.08 | 12.13 | 12.07 |
| 100 Mg | 12.11 | 12.98 | 12.22 | 12.44 | 12.29 | 13.17 | 12.41 | 12.62 |
| 100 K+50 Mg | 13.09 | 13.18 | 13.22 | 13.16 | 13.28 | 13.37 | 13.42 | 13.36 |
| 100 K + 100 Mg | 13.52 | 13.56 | 13.61 | 13.56 | 13.73 | 13.76 | 13.81 | 13.77 |
| 200 K+ 50 Mg | 14.07 | 14.12 | 14.14 | 14.11 | 14.28 | 14.34 | 14.36 | 14.33 |
| 200 K+100 Mg | 14.72 | 14.84 | 14.90 | 14.82 | 14.94 | 15.06 | 15.12 | 15.04 |
| Mean (A) | 12.65 | 12.80 | 12.76 | --- | 12.84 | 13.00 | 12.95 | --- |
| LSD at 0.05 | A= 0.03 | B=0.01 | AXB=0.05 | | A= 0.03 | B=0.02 | AXB=0.05 | |
| | | | | Fe in fruit ppm | | | | |
| Control | 10.73 | 10.77 | 10.80 | 10.77 | 10.89 | 10.93 | 10.97 | 10.93 |
| 100 K | 11.73 | 11.78 | 11.80 | 11.77 | 11.91 | 11.95 | 11.98 | 11.95 |
| 200 K | 12.10 | 12.12 | 12.18 | 12.13 | 12.28 | 12.30 | 12.36 | 12.32 |
| 50 Mg | 11.82 | 11.90 | 11.95 | 11.89 | 11.99 | 12.08 | 12.13 | 12.07 |
| 100 Mg | 12.11 | 12.98 | 12.22 | 12.44 | 12.29 | 13.17 | 12.41 | 12.62 |
| 100 K+50 Mg | 13.09 | 13.18 | 13.22 | 13.16 | 13.28 | 13.37 | 13.42 | 13.36 |
| 100 K + 100 Mg | 13.52 | 13.56 | 13.61 | 13.56 | 13.73 | 13.76 | 13.81 | 13.77 |
| 200 K+ 50 Mg | 14.07 | 14.12 | 14.14 | 14.11 | 14.28 | 14.34 | 14.36 | 14.33 |
| 200 K+100 Mg | 14.72 | 14.84 | 14.90 | 14.82 | 14.94 | 15.06 | 15.12 | 15.04 |
| Mean (A) | 12.65 | 12.80 | 12.76 | --- | 12.84 | 13.00 | 12.95 | --- |
| LSD at 0.05 | A= 0.03 | B=0.01 | AXB=0.05 | | A= 0.03 | B=0.02 | AXB=0.05 | |

K= $K_2SO_4$ Mg= Mg $SO_4$ B=Boron

Soil application at rate 200 Kg. potassium +100 kg magnesium gave the high content from Fe in eggplant plant and fruit compared with other treatments in two tested seasons. Perhaps this is evidence of increased rate of potassium and magnesium fertilizer is necessary for an appropriate concentration of Fe in the plant and fruits when compared with single or dual fertilizer.

The interacted treatments of the dual application at rate 200 Kg. potassium +100 kg magnesium with the foliar application at rate 10 ppm B application had the most significant effects on Fe content (ppm) in eggplant plant, whereas the lowest were with the single application of K and Mg in two seasons.

Data in Table (10) showed positive effects on the extractable amount of N, P and K (ppm) in soil after harvesting for the studied treatments. Generally the highest values at $1^{st}$ (17.6 ppm) for N, (5.24 ppm) for P and (42.67ppm) for K in soil at addition 200kg $K_2SO_4$+ 100 Mg $SO_4$. Where, the available nutrients of N, P and K after harvesting at the $2^{nd}$ season were (17.9), (5.37) and (44) ppm for N, P and K respectively at addition 200kg $K_2SO_4$+ 100 Mg $SO_4$.

With respect to the effect of foliar fertilizer with B; it is clearly the increasing the available amount of N, P and K (ppm ) in soil after harvesting. Furthermore, the highest mean values of the available N, P and K in soil after harvesting were associated with due to spraying B at (20 ppm) in the studied two seasons. From the aforementioned it could be concluded that raising application fertilizers K, Mg and B package all of this may be attributed to ameliorating effect in experimental soil leads to increasing available nutrient in soil.

Table 10: Effect of K, Mg and B fertilizer on the available amount N, P and K (ppm) in soil after harvesting during 2014/2015 and 2015/2016 seasons

| | First season | | | | Second season | | | |
|---|---|---|---|---|---|---|---|---|
| | B foliar spray (ppm) | | | | B foliar spray (ppm) | | | |
| Fertilizer treatments | 0 | 10 | 20 | Mean (B) | 0 | 10 | 20 | Mean (B) |
| | | | | N | | | | |
| Control | 15.00 | 15.10 | 15.30 | 15.13 | 15.10 | 15.20 | 15.40 | 15.23 |
| 100 K | 16.00 | 16.20 | 16.20 | 16.13 | 16.10 | 16.30 | 16.40 | 16.27 |
| 200 K | 17.10 | 17.30 | 17.50 | 17.30 | 17.10 | 17.60 | 17.70 | 17.47 |
| 50 Mg | 16.30 | 16.50 | 16.60 | 16.47 | 16.30 | 16.70 | 16.80 | 16.60 |
| 100 Mg | 16.60 | 16.80 | 16.90 | 16.77 | 16.70 | 16.90 | 17.10 | 16.90 |
| 100 K+50 Mg | 17.00 | 17.20 | 17.30 | 17.17 | 17.20 | 17.40 | 17.60 | 17.40 |
| 100 K + 100 Mg | 17.10 | 17.30 | 17.60 | 17.33 | 17.20 | 17.50 | 17.80 | 17.50 |
| 200 K+ 50 Mg | 17.20 | 17.40 | 17.60 | 17.40 | 17.30 | 17.60 | 17.90 | 17.60 |
| 200 K+100 Mg | 17.30 | 17.60 | 17.90 | 17.60 | 17.70 | 17.80 | 18.20 | 17.90 |
| Mean | 16.62 | 16.82 | 16.99 | --- | 16.74 | 17.00 | 17.21 | --- |
| | | | | P | | | | |
| Control | 3.20 | 3.30 | 3.40 | 3.30 | 3.30 | 3.30 | 3.40 | 3.33 |
| 100 K | 3.60 | 3.80 | 3.80 | 3.73 | 3.70 | 3.90 | 3.90 | 3.83 |
| 200 K | 4.10 | 4.20 | 4.10 | 4.13 | 4.30 | 4.20 | 4.30 | 4.27 |
| 50 Mg | 4.00 | 4.10 | 4.20 | 4.10 | 4.00 | 4.10 | 4.30 | 4.13 |
| 100 Mg | 4.30 | 4.40 | 4.60 | 4.43 | 4.30 | 4.50 | 4.70 | 4.50 |
| 100 K+50 Mg | 4.53 | 4.62 | 4.63 | 4.59 | 4.55 | 4.63 | 4.68 | 4.62 |
| 100 K + 100 Mg | 4.70 | 4.75 | 4.78 | 4.74 | 4.72 | 4.77 | 4.78 | 4.76 |
| 200 K+ 50 Mg | 4.79 | 4.80 | 4.82 | 4.80 | 5.00 | 5.04 | 5.07 | 5.04 |
| 200 K+100 Mg | 4.93 | 5.20 | 5.60 | 5.24 | 5.02 | 5.40 | 5.70 | 5.37 |
| Mean | 4.24 | 4.35 | 4.44 | --- | 4.32 | 4.43 | 4.54 | --- |
| | | | | K | | | | |
| Control | 21.00 | 22.00 | 23.00 | 22.00 | 23.00 | 23.00 | 24.00 | 23.33 |
| 100 K | 29.00 | 31.00 | 32.00 | 30.67 | 30.00 | 32.00 | 34.00 | 32.00 |
| 200 K | 41.00 | 43.00 | 44.00 | 42.67 | 42.00 | 44.00 | 46.00 | 44.00 |
| 50 Mg | 31.00 | 32.00 | 33.00 | 32.00 | 32.00 | 33.00 | 34.00 | 33.00 |
| 100 Mg | 30.00 | 31.00 | 32.00 | 31.00 | 33.00 | 34.00 | 34.00 | 33.67 |
| 100 K+50 Mg | 37.80 | 38.90 | 39..1 | 38.60 | 38.40 | 40.20 | 40.30 | 39.63 |
| 100 K + 100 Mg | 36.70 | 39.20 | 39.40 | 38.43 | 40.30 | 40.80 | 40.90 | 40.67 |
| 200 K+ 50 Mg | 40.10 | 41.30 | 41.60 | 41.00 | 40.60 | 40.80 | 42.00 | 41.13 |
| 200 K+100 Mg | 41.30 | 41.40 | 41.60 | 41.43 | 41.40 | 41.60 | 41.90 | 41.63 |
| Mean | 34.21 | 35.53 | 31.84 | --- | 35.63 | 36.60 | 37.46 | --- |

K= $K_2SO_4$ Mg= Mg $SO_4$ B=Boron

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